The Consultative Committee for Space Data Systems

Draft Recommendation for
Space Data System Standards

CCSDS SPACE LINK PROTOCOLS OVER ETSI DVB-S2 STANDARD

DRAFT RECOMMENDED STANDARD

CCSDS 131.3-P-1.1

PINK SHEETS

April 2021

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1 INTRODUCTION

1.1 BACKGROUND

The high demand in TV broadcasting has pushed the European Telecommunications Standards Institute (ETSI) to define a new satellite communication standard called Digital Video Broadcasting—Satellite—Second Generation (DVB-S2) (reference [1]). This standard is suited to high data rate transmissions, and proposes variable or adaptive coding and modulation with high power and bandwidth efficiencies.

1.2 PURPOSE

The purpose of this document is to define a recommended interface between CCSDS Space Link Protocols (references [3], ~~and~~ [4], and [7]) and the DVB-S2 telecom standard (reference [1]), and to recommend options of the DVB-S2 standard suited to high data rate ~~telemetry~~transmission applications, such as Earth Exploration Satellite Services (EESS) payload telemetry and ground-to-space and space-to-space applications (Space Research Services [SRS], inter-satellite links).

1.3 SCOPE

The DVB-S2 standard (reference [1]) proposes advanced modulation techniques (QPSK, 8PSK, 16APSK, and 32APSK) and a wide range of coding rates (from 1/4 to 9/10) with near-Shannon coding schemes (LDPC codes). This high number of modulation and coding schemes allows a wide range of possibilities to satisfy specific mission constraints.

Moreover, to maximize the ~~telemetry~~ system throughput, it appears possible to adapt the transmitted waveform (and the useful data rate) to the variable conditions of the link. The DVB-S2 standard can actually implement Variable Coding and Modulation (VCM) mode, which adapts the transmission scheme to the channel conditions following a predetermined schedule (for example, following a dynamic link budget). When a channel is available to provide feedback (e.g., via a ~~tele~~command link), the transmission scheme can be dynamically adjusted using the Adaptive Coding and Modulation (ACM) mode.

The use of the DVB-S2 standard for telemetry makes possible the use of generic Very High Scale Integrated Circuits (VHSIC) Hardware Description Language (VHDL) Intellectual Property (IP) modules for developments. The use of a widely implemented standard simplifies finding transmitting or receiving equipment to check compatibility. Finally, for the ground part, some telecom DVB-S2 receivers or Application Specific Integrated Circuits (ASICs) developed for the telecom market could be reused.

This Recommended Standard is an adaptation profile describing how to use the DVB-S2 standard to transmit CCSDS Transfer Frames ~~for telemetry purpose~~. The interface between CCSDS and DVB-S2 is based on the Attached Synchronization Marker (ASM) and Channel Access Data Unit (CADU) already introduced in reference [2].

DVB-S2 is used in this adaptation profile as a complete and self-sufficient standard, and definitions and specifications taken from DVB-S2 are applicable only in the context of this Recommended Standard. However, individual DVB-S2 functions or components (e.g., VCM/ACM, 8-PSK, and higher-order modulations) might be reused, redefined, and/or respecified by CCSDS in future Recommended Standards.

1.4 APPLICABILITY

This Recommended Standard applies to the creation of Agency standards and to data communications over space links between CCSDS Agencies in cross-support situations for near ~~Earth Exploration Satellite Services (EESS)~~ ~~payload telemetry~~EESS and SRS. This Recommended Standard includes comprehensive specification of the data formats and procedures for inter-Agency cross support. It is neither a specification of, nor a design for, real systems that may be implemented for existing or future missions.

The Recommended Standard specified in this document is to be invoked through the normal standards programs of each CCSDS Agency and is applicable to those missions for which cross support based on capabilities described in this Recommended Standard is anticipated. Where mandatory capabilities are clearly indicated in sections of this Recommended Standard, it is mandatory to implement them when this document is used as a basis for cross support. Where options are allowed or implied, implementation of these options is subject to specific bilateral cross-support agreements between the Agencies involved.

1.5 DOCUMENT STRUCTURE

Section 1 presents the background, purpose, scope, applicability, and rationale of this Recommended Standard and lists the conventions, definitions, and references used throughout the document.

Section 2 provides an overview of the system architecture.

Section 3 specifies the CADU stream generation.

Section 4 specifies the DVB-S2 transmission of the CADU stream.

Section 5 specifies managed parameters.

Annex A provides the service definition.

Annex B discusses security, Space Assigned Numbers Authority (SANA), and patent considerations.

Annex C lists acronyms and terms used within this document.

Annex D lists MODCOD available in the DVB-S2 standard.

[1] *Digital Video Broadcasting (DVB); Second Generation Framing Structure, Channel Coding and Modulation Systems for Broadcasting, Interactive Services, News Gathering and other Broadband Satellite Applications*. ETSI EN 302 307 V1.2.1 (2009-08). Sophia-Antipolis: ETSI, 2009.

NOTE – ETSI standards are available for free download at http://www.etsi.org.

[2] *TM Synchronization and Channel Coding*. Issue 3. Recommendation for Space Data System Standards (Blue Book), CCSDS 131.0-B-3. Washington, D.C.: CCSDS, September 2017.

[3] *TM Space Data Link Protocol*. Issue 2. Recommendation for Space Data System Standards (Blue Book), CCSDS 132.0-B-2. Washington, D.C.: CCSDS, September 2015.

[4] *AOS Space Data Link Protocol*. Issue 3. Recommendation for Space Data System Standards (Blue Book), CCSDS 732.0-B-3. Washington, D.C.: CCSDS, September 2015.

[5] *Information Technology—Open Systems Interconnection—Basic Reference Model: The Basic Model*. International Standard, ISO/IEC 7498-1:1994. 2nd ed. Geneva: ISO, 1994.

[6] *Information Technology—Open Systems Interconnection—Basic Reference Model—Conventions for the Definition of OSI Services*. International Standard, ISO/IEC 10731:1994. Geneva: ISO, 1994.

[7] *Unified Space Data Link Protocol*. Issue 1. Recommendation for Space Data System Standards (Blue Book), CCSDS 732.1-B-1. Washington, D.C.: CCSDS, October 2018.

2 OVERVIEW

2.1 ARCHITECTURE

Figure 2-1 illustrates the relationship of this Recommended Standard to the Open Systems Interconnection reference model (reference [5]). Two sublayers of the Data Link Layer are defined for CCSDS space link protocols. The TM and AOS Space Data Link Protocols and the Unified Space Data Link Protocol (USLP) specified in references [3], ~~and~~ [4], and [7], respectively, correspond to the Data Link Protocol Sublayer and provide functions for transferring data using the protocol data unit called the Transfer Frame. The Synchronization and Channel Coding Sublayer provides methods of synchronization and channel coding for transferring Transfer Frames over a space link, while the Physical Layer provides the RF and modulation methods for transferring a stream of bits over a space link in a single direction.

This Recommended Standard covers the functions of both the Synchronization and Channel Coding Sublayer and the Physical Layer.

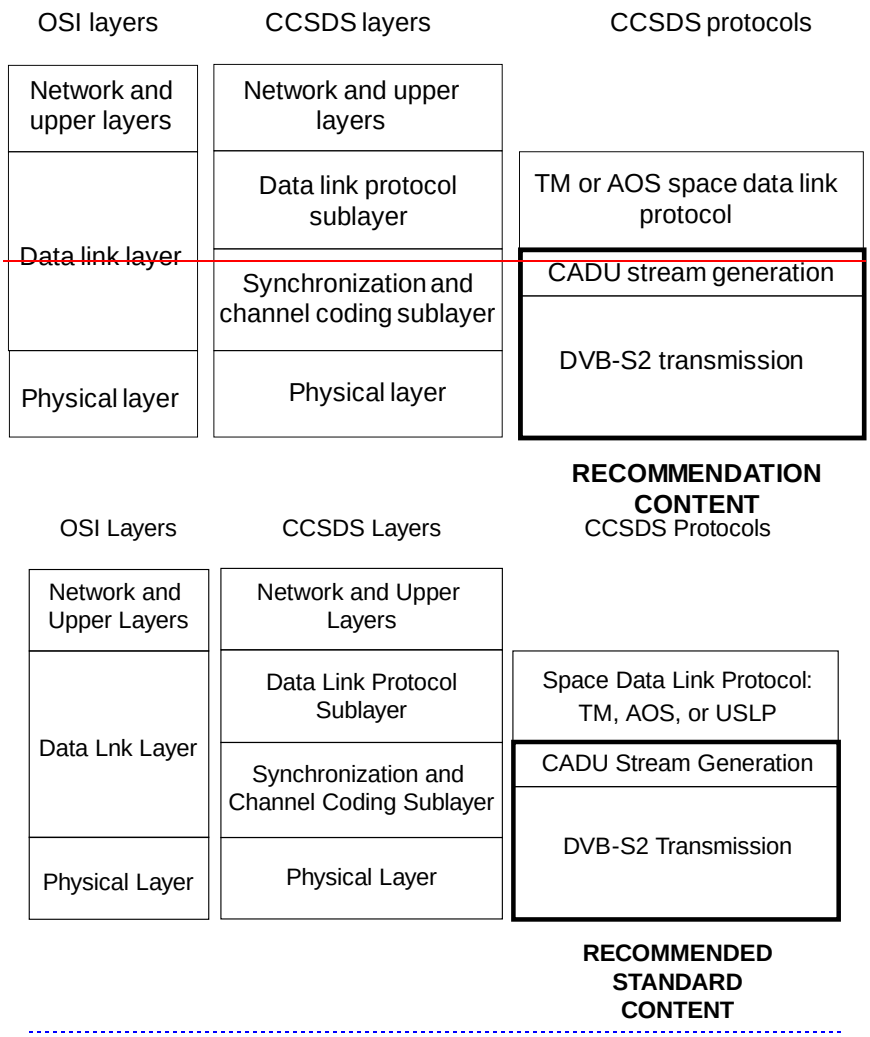

Figure 2-1: Relationship with OSI Layers

2.2 SUMMARY OF FUNCTIONS

2.2.1 GENERAL

This Recommended Standard provides the following functions for transferring Transfer Frames via a stream of bits over a space link:

a) pseudo-randomizing;

b) error correction coding and modulation;

c) Transfer Frame synchronization;

d) Transfer Frame validation.

2.2.2 PSEUDO-RANDOMIZING

Pseudo-randomizing is specified in the DVB-S2 standard. No other pseudo-randomizing of Transfer Frames is required.

2.2.3 ERROR CORRECTION CODING AND MODULATION

Error correction coding and modulation are specified in the DVB-S2 standard. No other error correction coding of Transfer Frames is required.

2.2.4 TRANSFER FRAME SYNCHRONIZATION

This Recommended Standard specifies an Attached Sync Marker (ASM) for synchronizing Transfer Frames at the receiver.

2.2.5 TRANSFER FRAME VALIDATION

After decoding is performed, the upper layers at the receiving end also need to know whether or not each decoded Transfer Frame can be used as a valid data unit; i.e., an indication of the quality of the received frame is needed. This function is called Frame Validation. In this Recommended Standard, the Frame Error Control Field defined in references [3], ~~and~~ [4], and [7] is used for Transfer Frame Validation at the receiver.

2.3 INTERNAL ORGANIZATION

2.3.1 SENDING END

2.3.1.1 General

Figure 2-2 illustrates the frame structures and stream formats at different stages of processing for the sending end.

3 CADU STREAM GENERATION

3.1 OVERVIEW

3.1.1 CCSDS Transfer Frame synchronization is necessary at the receiver. Consequently an ASM is introduced before transmission. Error correction coding and pseudo-randomization are performed at the DVB-S2 transmission level.

3.2 INPUT CCSDS TRANSFER FRAMES

3.2.1 Input Transfer Frames shall be either TM Transfer Frames as specified in reference [3], or AOS Transfer Frames as specified in reference [4], or USLP Transfer Frame as specified in reference [7].

NOTE – Per A2.1, only fixed-length frames are accepted when using USLP Transfer Frames.

3.2.2 The Transfer Frames length shall vary between the following minimum and maximum values: 223 octets (1784 bits) and ~~2048~~65536 octets (~~16384~~524288 bits).

3.2.3 Error correction coding and pseudo-randomization shall be performed **only** at the DVB-S2 transmission level.

3.3 CHANNEL ACCESS DATA UNIT

3.3.1 For each Transfer Frame, the system shall construct a CADU containing the ASM and the Transfer Frame.

3.3.2 The ASM shall be the 32-bit (4-octet) marker with value 1ACFFC1D in hex defined in reference [2].

NOTE – In his book, the CADU stream consists of a stream of fixed-length Transfer Frames with each Transfer Frame immediately preceded by an ASM. The ASM attached to a Transfer Frame immediately follows the end of the previous Transfer Frame.

5 MANAGED PARAMETERS

5.1 OVERVIEW

5.1.1 Some parameters associated with coding, synchronization, and modulation are handled by management rather than by inline communications protocol. The managed parameters are generally those which tend to be static for long periods of time, and whose change generally signifies a major reconfiguration of the modulation, synchronization, and channel coding systems associated with a particular mission, i.e., parameters that are fixed within a mission phase. However, as mentioned in annex A, the coding and modulation scheme defined in this book also supports parameters that can be changed from one time interval to the next, within a sequence of time intervals in a mission phase. These two types are referenced in this section respectively as Permanent Managed Parameters and Variable Managed Parameters.

5.1.2 Through the use of a management system, management conveys the required information to the coding, synchronization, and modulation systems.

5.1.3 In this section, the managed parameters used by coding, synchronization and modulation systems are listed. These parameters are defined in an abstract sense and are not intended to imply any particular implementation of a management system.

5.2 PERMANENT MANAGED PARAMETERS

5.2.1 GENERAL

5.2.1.1 All the managed parameters specified in this section shall be fixed for all Transfer Frames on a Physical Channel during a given Mission Phase.

5.2.1.2 The Frame Error Control Field defined in reference [3], ~~or~~ reference [4], or reference [7] shall be present.

NOTES

1 The Frame Error Control Field is used for Frame Validation as mentioned in 2.2.5.

2 Reference [7] defines two types of Frame Error Control (CRC-16 and CRC-32). The CRC-16 procedure is identical to the one defined in references [3] and [4]. The CRC-32 procedure is only available in reference [7].

5.2.2 MANAGED PARAMETERS FOR TRANSFER FRAME SYNCHRONIZATION AND VALIDATION

The managed parameters for Transfer Frame Synchronization and Validation shall be those specified in table 5-1.

Table 5-1: Permanent Managed Parameters for Transfer Frame Synchronization and Validation

Managed Parameter	Allowed Values
Transfer Frame Length (octets)	Integer: 223 to ~~2048~~65536 octets
CRC procedure	CRC-16 or CRC-32

5.2.3 MANAGED PARAMETERS FOR DVB-S2 TRANSMISSION

5.2.3.1 The managed parameters for DVB-S2 transmission shall be those specified in table 5-2.

NOTE – MODCOD, FECFRAME size, and pilot insertion status are variable managed parameters and are indicated with an asterisk in table 5-2.

Table 5-2: Permanent Managed Parameters for DVB-S2 Transmission

Managed Parameter	Allowed Values
Transmission mode	CCM, VCM, or ACM.
Baseband pulse shaping roll-off factor	0.2, 0.25, or 0.35.
Dummy PLFRAME utilization	YES or NO.
Scrambling code number n	Integer: 0 to 262141 (see paragraph 5.5.4 of reference [1]).
Number of MODCOD* supported during a given mission phase	Integer: 1 to ~~28~~29 (for MODCOD coding, see table 12 paragraph 5.5.2.2 of reference [1]).
List of MODCOD* supported during a given mission phase	List of integers (dimension = 'Number of MODCOD supported during a given mission phase'). Each integer of the list is in the range ~~1~~0 to 28 and corresponds to a supported MODCOD. (For MODCOD coding, see table 12 paragraph 5.5.2.2 of reference [1].)
Supported FECFRAME size*	Short, Normal, or both.
Supported pilot insertion status*	ON, OFF, or both.

NOTE – Annex D contains a list of supported MODCOD.

5.3 VARIABLE MANAGED PARAMETERS

The managed parameters specified in table 5-3 shall be fixed on a Physical Channel within one interval of a given Mission Phase.

Table 5-3: Variable Managed Parameters

Managed Parameter	Allowed Values
Current MODCOD	Integer: ~~1~~0 to 28 (for MODCOD coding, see table 12 paragraph 5.5.2.2 of reference [1]).
Current FECFRAME size	Short or Normal.
Current pilot insertion status	ON or OFF.

NOTE – These variable managed parameters are indicated in the PLHEADER of the transmitted signal; it is consequently not needed to provide them to the receiver working in VCM/ACM mode.

ANNEX A

SERVICE DEFINITION

(NORMATIVE)

A1 OVERVIEW

A1.1 BACKGROUND

This annex provides service definition in the form of primitives, which present an abstract model of the logical exchange of data and control information between the service provider and the service user. The definitions of primitives are independent of specific implementation approaches.

The parameters of the primitives are specified in an abstract sense and specify the information to be made available to the user of the primitives. The way in which a specific implementation makes this information available is not constrained by this specification. In addition to the parameters specified in this annex, an implementation can provide other parameters to the service user (e.g., parameters for controlling the service, monitoring performance, facilitating diagnosis, and so on).

A2 OVERVIEW OF THE SERVICE

A2.1 The present 'CCSDS Space Link Protocols over ETSI DVB-S2' Recommended Standard provides unidirectional (one way) transfer of a sequence of fixed-length TM, ~~or~~ AOS, or USLP Transfer Frames at constant frame rate over a Physical Channel across a space link, with optional error detection/correction.

A2.2 The value of the constant frame rate can be changed from one time interval to the next, within a sequence of time intervals in a mission phase. There can be multiple time intervals within a mission phase. This annex does not specify the method for synchronizing the data exchange between the service user and the service provider when there is a change of frame rate: the synchronization is considered to be part of system management and is out of the scope of this annex.

A2.3 Only one user can use this service on a Physical Channel, and Transfer Frames from different users are not multiplexed together within one Physical Channel.

A3 SERVICE PARAMETERS

A3.1 FRAME

A3.1.1 The Frame parameter is the service data unit of this service and shall be either a TM Transfer Frame defined in reference [3], ~~or~~ an AOS Transfer Frame defined in reference [4], or a USLP Transfer Frame defined in reference [7].

A3.1.2 The length of any Transfer Frame transferred on a Physical Channel is established by management.

A3.2 QUALITY INDICATOR

The Quality Indicator parameter shall be used to notify the user at the receiving end of the service that there is an uncorrectable error in the received Transfer Frame.

A3.3 SEQUENCE INDICATOR

The Sequence Indicator parameter shall be used to notify the user at the receiving end of the service that one or more Transfer Frames of the Physical Channel have been lost as the result of a loss of frame synchronization.

A4 SERVICE PRIMITIVES

A4.1 GENERAL

A4.1.1 The service primitives associated with this service are:

a) ChannelAccess.request;

b) ChannelAccess.indication.

A4.1.2 The ChannelAccess.request primitive shall be passed from the service user at the sending end to the service provider to request that a Frame be transferred through the Physical Channel to the user at the receiving end.

A4.1.3 The ChannelAccess.indication shall be passed from the service provider to the service user at the receiving end to deliver a Frame.

A4.2 ChannelAccess.request

A4.2.1 Function

The ChannelAccess.request primitive is the service request primitive for this service.

RF	radio frequency
SNR	signal power to noise power ratio
SOF	start of frame
SRC	square root raised cosine shaping
SRS	Space Research Services
SYNC	synchronization octet
TM	telemetry
USLP	Unified Space data Link Protocol
VCM	variable coding and modulation
VHDL	VHSIC ~~(Very High Scale Integrated Circuits)~~ Hardware Description Language
VHSIC	Very High Speed Integrated Circuits

ANNEX D

DVB-S2 SPECTRAL EFFICIENCIES AND MODCOD IDENTIFIERS

(INFORMATIVE)

The following spectral efficiencies consider the CADU stream as the useful content to be transmitted. Consequently, the required bit rate at the input of the DVB-S2 transmitter is equal to the product of the selected spectral efficiency listed in the following table with the channel symbol rate used on the physical link.

MODCOD	Modulation	LDPC code identifier	spectral efficiency [bits/symbol]			
			short frame with pilots	short frame without pilots	normal frame with pilots	normal frame without pilots
0	Unmodulated	None	0	0	0	0
1	QPSK	1/4	0.3575	0.3653	0.4786	0.4902
2	QPSK	1/3	0.6155	0.6291	0.6408	0.6564
3	QPSK	2/5	0.7446	0.7609	0.7706	0.7894
4	QPSK	1/2	0.8306	0.8488	0.9653	0.9889
5	QPSK	3/5	1.1317	1.1565	1.1600	1.1883
6	QPSK	2/3	1.2607	1.2884	1.2908	1.3223
7	QPSK	3/4	1.3897	1.4203	1.4521	1.4875
8	QPSK	4/5	1.4757	1.5082	1.5494	1.5872
9	QPSK	5/6	1.5618	1.5961	1.6153	1.6547
10	QPSK	8/9	1.6908	1.7280	1.7244	1.7665
11	QPSK	9/10			1.7460	1.7886
12	8PSK	3/5	1.6920	1.7253	1.7396	1.7800
13	8PSK	2/3	1.8850	1.9220	1.9357	1.9806
14	8PSK	3/4	2.0779	2.1188	2.1775	2.2281
15	8PSK	5/6	2.3351	2.3811	2.4223	2.4786
16	8PSK	8/9	2.5280	2.5778	2.5859	2.6460
17	8PSK	9/10			2.6184	2.6792
18	16APSK	2/3	2.5052	2.5488	2.5746	2.6372
19	16APSK	3/4	2.7616	2.8097	2.8963	2.9667
20	16APSK	4/5	2.9326	2.9836	3.0905	3.1656
21	16APSK	5/6	3.1035	3.1575	3.2219	3.3002
22	16APSK	8/9	3.3599	3.4184	3.4395	3.5231
23	16APSK	9/10			3.4827	3.5673
24	32APSK	3/4	3.4192	3.4931	3.6233	3.7033
25	32APSK	4/5	3.6308	3.7093	3.8662	3.9516
26	32APSK	5/6	3.8424	3.9255	4.0306	4.1195
27	32APSK	8/9	4.1599	4.2498	4.3029	4.3979
28	32APSK	9/10			4.3569	4.4530